

RUNNING HEAD: Do masculine men smell better?

Do masculine men smell better? An association between skin color masculinity and
female preferences for body odor

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Abstract

A recent study claimed face skin color as a sexually dimorphic variable that influences attractiveness preferences in mate choice. Thereby, skin color may assume the role of a mate quality signal influencing attractiveness preferences. As body odor is linked to attractiveness, this study aimed to explore whether the odors of men with more masculine facial skin color would be evaluated more positively than odors from less masculine men. Female raters were presented with body odors of 18 men and were asked to rate them in various characteristics. Multilevel modeling revealed that the odors of the donors with more masculine color were rated not only as more attractive, more pleasant, and sexier, but also healthier. This indicates that odor associated with men with more masculine skin color is attractive, just as other sexually dimorphic traits. Furthermore, we found a negative relation between skin color masculinity and perceived odor maleness. Regarding this last finding, a new discussion is introduced with respect to the influence of cognitive stereotypes in odor judgments. Altogether, the study supports the possibility that chemosensory signals may be communicating signs of mate quality associated with masculinity.

Keywords

Attractiveness; male coloration; mate preferences; olfaction; scent; sexual dimorphism.

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1. Introduction

Several studies have demonstrated that olfactory cues seem to have an important role in human sexual behavior (Kohl *et al.* 2001; Lübke and Pause 2015), especially in women's mate choice (Havlíček *et al.* 2008; Herz and Cahill 1997; Herz and Inzlicht 2002). Women show superiority in sensitivity-detection and recognition-identification body odor tasks compared to men (Brand and Millot 2001) and seem to be more sensitive to the influence of body scents in their sexual interest (Herz and Cahill 1997). In fact, female participants seem to prefer the odors of men that are more dominant (Havlíček *et al.* 2005) and more symmetric (Thornhill and Gangestad 1999). During puberty, when sexually dimorphic traits begin to emerge, the development of sebaceous and apocrine skin glands occurs which suggests that masculinity may be imprinted in human odor (Wyatt 2015).

Heterosexual women might feel attracted to masculine traits in men, namely scent cues, since masculinity is believed to signal genetic fitness and/or intrasexual competitiveness. The preference for masculinity traits in sexual partners might lower the risk of infection for women, since masculine healthy males may be less likely to contract and spread diseases (Kirkpatrick and Ryan 1991), or at least ensure protection and resources for them and their offspring (Puts 2010). Several studies have reported that preferences for masculinity, especially in odor cues, are dependent on the menstrual cycle of the female participants (Havlíček *et al.* 2005; Thornhill and Gangestad 1999). Those studies report that women prefer the scent of more masculine males only near ovulation, and this occurs only for non-pill users. However, other studies have failed to find differences across the ovulatory cycle (Rantala *et al.* 2006).

To our knowledge, Allen *et al.* (2016), while studying the effect of artificial fragrances on preferences for human body odors, were the first to investigate how perceived facial

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masculinity correlates with perceived body odor masculinity. They found a positive correlation between face masculinity ratings given by both sex participants with odor masculinity ratings given by female participants. Other studies explored the preference for masculinity in odor cues relying on men's testosterone levels (Thornhill *et al.* 2013), second-to-fourth digit ratio (2D:4D) (Roberts *et al.* 2011), or women's exposure to androstenone (Cornwell *et al.* 2004; Grammer 1993), androstenol (Savic and Berglund 2010) or androstadienone (Cornwell *et al.* 2004). Acknowledging the debate on whether these last chemicals do in fact represent real human pheromones (Wyatt 2015) and the inconsistent results regarding the attractiveness level of face shape masculinity, with some studies reporting preferences for femininity (e.g. DeBruine *et al.* 2010; Little and Hancock 2002; Perrett *et al.* 1998) and others suggesting a preference for masculinity (e.g. DeBruine *et al.* 2006; Little and Mannion 2006) in male faces, it becomes important to consider other measures of masculinity when investigating odor preferences for sexually dimorphic cues. In this study, we measured masculinity through a new trait which has received little attention: sexually dimorphic skin color.

One of the most typical sexual dimorphic traits that distinguish males and females throughout the animal kingdom is phenotypic color. Sexual dichromatism is frequent between species of birds (Bortolotti *et al.* 1996; Dale *et al.* 2015), amphibians (Bell and Zamudio 2012) and fish (Kodric-Brown 1998). Human skin color, apart from being an important indicator of current health (Fink *et al.* 2012; Re *et al.* 2011; Stephen *et al.* 2009b; Whitehead *et al.* 2012), has been shown to be different between human females and males (Van den Berghe and Frost 1986) but also to be considered attractive in mate preferences (Carrito *et al.* 2016). The multi-million industry of facial cosmetics is itself a proof of how much skin color influences the perception of facial beauty, and much of cosmetics use seems to serve the purpose of exaggerating sexual dimorphic differences (Russell 2009). A recent proposal

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claimed skin color, as an indicator of current health condition, to be a stronger determinant of perceived attractiveness than shape masculinity (Scott *et al.* 2010; Stephen *et al.* 2012). In a previous study of Carrito and colleagues (2016), participants chose to masculinize the color of male faces more than the color of female faces when asked to modify the faces to define the most attractive appearance. A masculine skin color that is darker, yellower and redder than a more feminine skin color, might represent direct benefits to the female partner and hence be attractive for women.

Accordingly, the goal of our study was to investigate whether the odor of men with more masculine facial skin color would be more attractive to heterosexual women. We expected odors of donors with more masculine skin color to be preferred by female raters compared to the ones from men with less masculine skin color. Along with attractiveness, women were asked to rate other characteristics of the odors: pleasantness, sexiness, health, familiarity, intensity, arousal, masculinity and dominance.

2. Method

2.1. Participants

Detailed written informed consent was obtained from all participants prior to enrolment, and all aspects of the study were performed in accordance with the Declaration of Helsinki for experimentation with human subjects. The study was part of a project that was approved by the Scientific Council of the University of Aveiro, which assesses its ethical, formal and scientific aspects. A socio-demographic questionnaire open to the academic community was available online, in order to recruit female participants for the experimental task. Forty-two women, aged between 18 and 39 ($M = 24.24$ years, $SD = 6.43$), from a total of 116, were selected to participate in the study.

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The inclusion criteria were ethnicity (Caucasian), age (between 18 and 40 years old), health status (not reporting any physical, neurological or mental disease), not being pregnant and not currently taking any medication. The upper limit in age was a deliberate choice aiming to avoid the possible influence of hormonal effects related with participants' menopause (Cobey *et al.* 2015; Jones *et al.* 2011). The absence of use of hormonal contraceptives was also a requirement since it has been shown that hormonal contraceptives influence sensitivity to olfactory stimuli (Lundström *et al.* 2006; Renfro and Hoffmann 2013) and also attractiveness judgments in other domains (Little *et al.* 2013; Roberts *et al.* 2014). All participants reported having regular menstrual cycles (28 – 40 days). Participants were asked about the date of the onset of their last menstruation (day 1). Fertile women were considered when being on days 9–15 of their cycle at the time of the experiment (N = 10) while others were considered to be in non-fertile phases of the cycle (N = 31) (Havlíček and Lenochová 2006). One participant could not recall the date of the onset of her last menstruation and her fertility status was not considered.

Participants were asked to refrain from eating (e.g., gum, candies), drinking coffee, or using any scented products that could interfere with their olfactory ability for 1 hour before testing.

2.2. Materials

2.2.1. Skin color measurements

The first phase of this work focused on trying to establish a measure of facial skin color sexual dimorphism for the young adult Portuguese population. To do so, it was necessary to collect a sample of skin color measurements of men and women in order to calculate a representative skin color average, according to the International Commission on Illumination (CIE) $L^*a^*b^*$ values, typical of the male and female population. The CIELab

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color space is defined by L^* , a^* , and b^* values (L^* reflects degrees of lightness, and positive values of a^* and b^* reflect degrees of redness and yellowness, respectively) (Whitehead *et al.* 2012) and is designed to be perceptually uniform, with a change of one unit appearing to be of approximately the same magnitude regardless of its dimension (Martinkauppi 2002).

Therefore, skin color measurements were taken from 100 Caucasian university students, 50 women (aged between 18 and 37; $M = 21.14$, $SD = 3.89$) and 50 men (aged between 19 and 31; $M = 22.98$, $SD = 2.65$) who volunteered for skin color measurements. Exclusion criteria included the use of self-tanning products, recent physical effort, skin or infectious disease. The experimenter cleaned the skin on the forehead of each student with cotton and alcohol. Skin color was measured using a Konica Minolta Chroma Meter CR-400. The aperture of the Chroma meter was lightly held against the skin, in order to minimize pressure-induced blanching. White-point calibration was conducted before recording sessions. Recordings were repeated 3 times on the participant's forehead, and the most divergent value of the 3 was excluded from the analyses. Two men and 3 women were later excluded from the sample since the Euclidean (ΔE^*) distance between their two remaining skin color measurements was larger than 2. Finally, we averaged the two remaining values to obtain a unique L^* a^* b^* set of values for each participant.

Through this process of skin color measurement, average CIE $L^*a^*b^*$ values were assessed for male ($n = 48$) and female ($n = 47$) participants. Average male face skin color was $L^* = 65.37$, $a^* = 12.52$ and $b^* = 17.05$ and average female color was $L^* = 67.82$, $a^* = 11.02$ and $b^* = 15.85$. Average male face skin luminance (L^*) was significantly different from female average ($t(93) = -4.51$, $p < .001$), and the same was true for a^* ($t(93) = 3.77$, $p < .001$) and b^* ($t(93) = 3.08$, $p < .001$) color axes. A logistic regression was conducted in order to posteriorly calculate skin color masculinity scores of the male body odor donors. To do so, we considered the L^* a^* b^* values as predictors and the sex of participant as the outcome (men

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were scored as 1 and women as 0). The resulting model was significant, $\chi^2(3) = 26.96$, $p < .01$, R^2 (Nagelkerke) = .329, and was represented by the following equation: Sex = constant + $B1 \times L^* + B2 \times a^* + B3 \times b^*$, in which the constant = 7.2, $B1 = -.22$, $B2 = .25$ and $B3 = .27$. Logistic regression analyses revealed that skin color (L^* , a^* and b^*) predicted the sex correctly for 69.5% of participants.

A similar skin color measurement procedure was adopted to collect skin color measurements of the male body odor donors. Thirty-two male students volunteered, 14 of them being later excluded based on several criteria as described below. Male volunteers filled a socio-demographic questionnaire and 2 Visual Analogue Scales (VAS, 0 - 100 mm) that measured their own perceived stress and anxiety levels during the tasks. Only participants that reported low levels of stress or anxiety (< 50 in the stress/anxiety scales) were selected. Additional inclusion criteria were: ethnicity (Caucasian), age (over 18 but under 40 years old), avoidance of sun-tanning activities, health status (not reporting physical, mental or neurological diseases) and not currently taking any medication. The 18 male volunteers that fulfilled all requirements (aged between 18 and 34; $M = 23.83$, $SD = 3.94$) were selected for subsequent skin color measurements and body odor sampling. Regarding the skin color measurements, CIE $L^*a^*b^*$ values of participants' forehead skin were used to estimate the degree of skin color masculinity of each of the 18 donors. Based on the model presented previously, we calculated the masculinity score of each of the body odor donors ($M = 1.63$, $SD = 1.08$, Range: -0.31 – 3.86).

2.2.2. Sampling of donors' body odor

For the body odor sampling procedure, donors were given a kit with two cotton pads (Mercurochrome) and medical adhesive tape in a zip bag, a white cotton t-shirt, a towel and a hypoallergenic scent free gel wash (*Lactacyd Derma Gel*). Donors were instructed to refrain

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from using fragrant hygiene products (e.g., perfume, body lotions), smoking, eating spicy foods, garlic, and drinking alcohol, the day before the body odor sampling and until the end of the sampling, in order to avoid alterations of their natural body odor (Alho *et al.* 2015).

Donors were instructed to bathe early in the morning with the *Lactacyd Derma Gel* and to put in place the cotton pads under both armpits. After they had put on the white cotton t-shirt supplied, donors could also wear their personal clothes if they were clean (and fragrance free). Body odors were collected on the cotton pads attached to their armpits (Alho *et al.* 2015; Mitro *et al.* 2012). Donors wore the t-shirts for periods of 4 hours. The cotton pads were then collected, divided into equal size quadrants, stored in a closed zip-locked bag and frozen at -20°C.

The samples were thawed 1 h before the experimental task. Four pad quadrants were placed separately in wide-mouthed glass jars with lids and were used as body odor samples. To prevent contamination, odor samples were always handled with surgical gloves. Also, the time interval between storage and the last defrosting was less than 6 months (Lenochova *et al.* 2009).

2.3. Procedure

In the odor rating task, participants smelled each body odor sample for 3 s and rated them on their perceived attractiveness, sexiness, healthiness, familiarity, intensity, pleasantness, masculinity, dominance and arousal using a VAS (0-100 mm). The anchor points for the ratings were *not attractive* and *very attractive* for “attractiveness”, and the same format was applied to the rest of the traits. The specific instructions were as follows: “Place a mark on the lines below in order to indicate your judgement about the various characteristics of this odor”. The order of presentation of the traits to be rated was randomized between trials for each sample for each participant. Also, the order of presentation of the 18 odors was

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randomized and different for each participant. This task was repeated 18 times (one time for each odor sample).

3. Results

3.1. Notes on data analysis

All the analyses were performed using SPSS with Amos (v.22). Primary descriptive and correlational analyses considered male body odor donors as units of analyses (section 3.2), averaging the scores given by all female participants. However, because this methodology does not take into account the variability stemming from individual differences between raters, further analyses were performed taking into account the absolute values of the ratings given by each female rater for each odor sample. Multilevel analyses allowed the consideration of both the effect of female raters ($n = 42$; level 1) and the effect of male body odor donors ($n=18$; level 2) to be analyzed simultaneously rather than aggregating data by either one of them (Gildersleeve *et al.* 2012). This test was repeated for each of the dependent variables considered, addressing how the skin color masculinity score predicted each one of the ratings.

In order to avoid repeating conceptually similar evaluations and increasing the probability of one of the judgments becoming significant by chance, the ratings considered in all analyses were previously submitted to a dimension reduction procedure. Exploratory factor analyses allowed the extraction of 2 factors and the model was posteriorly improved using confirmatory factor analyses. Hence, the dependent variables considered in the previously mentioned multilevel analyses were not the individual ratings initially collected but the dimensions determined by the latter model.

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3.2. Descriptive statistics and correlations between ratings

In the first analyses performed, body odor donors were considered as units of analysis ($n = 18$), to investigate possible associations between the collected ratings. Table 1 shows descriptive statistics for all the rated traits.

Table 1. Descriptive statistics of the male odor ratings.

	Mean	SD	Range
Attractiveness	27.13	10.27	8.85 - 45.83
Pleasantness	33.84	13.56	7.26 - 53.29
Sexiness	25.35	9.20	9.70 - 43.55
Health	45.17	8.86	28.57 - 57.29
Masculinity	51.68	15.58	32.21 - 77.22
Dominance	36.44	9.48	24.12 - 53.45
Intensity	46.83	21.54	17.71 - 83.52
Arousal	34.78	9.73	20.14 - 51.62
Familiarity	27.90	6.66	20.02 - 46.83

Since the rating values were normally distributed (Shapiro-Wilk, $p > .05$), except for pleasantness, which showed acceptable skewness of .96 ($SE = .54$) and kurtosis of -.11 ($SE = 1.04$), Pearson correlations were performed. As observed in Table 2, there are multiple significant correlations between the ratings.

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Table 2. Correlations between odor ratings when considering male body donors as units of analysis.

	ATTR	PLEA	SEXI	HEAL	MASC	DOMI	INTE	AROU	FAMI
ATTR	---								
PLEA	.899**	---							
SEXI	.948**	.783**	---						
HEAL	.880**	.926**	.806**	---					
MASC	-.507*	-.783**	-.373	-.686**	---				
DOMI	-.385	-.651**	-.255	-.606**	.934**	---			
INTE	-.624**	-.835**	-.511*	-.814**	.948**	.878**	---		
AROU	-.329	-.622**	-.195	-.600**	.878**	.872**	.895**	---	
FAMI	-.201	-.482*	-.125	-.430	.715**	.664**	.659**	.750**	---

Note: * $p < .05$; ** $p < .01$. ATTR = Attractiveness; PLEA = Pleasantness; SEXI = Sexiness; HEAL = Health; MASC = Masculinity; DOMI = Dominance; INTE = Intensity; AROU = Arousal; FAMI = Familiarity.

3.3. Ratings – dimension reduction

Analyses were performed considering both body odor donors and female raters as units of analysis. Exploratory factor analysis, with Principal Component Analysis (PCA) as extraction method and varimax rotation with suppression of small coefficients (< 0.40), allowed the extraction of two main components: one including attractiveness, pleasantness, sexiness and health ratings; the other including masculinity, dominance, intensity and arousal ratings. To confirm the validity of these latent factors and to verify if the observed variables are legitimate representations of their latent factors, we conducted a confirmatory factor analysis. A new model, excluding both health and arousal, showed higher factor weights and individual reliabilities. Following the procedure used by Gildersleeve *et al.* (2012), we have grouped the attractiveness, pleasantness and sexiness ratings in a single latent factor which was called “Likeability”. In addition, we grouped the masculinity, dominance and intensity ratings in a factor called “Maleness”. The two-factor model (see Figure 1) revealed a good goodness-of-fit index ($GFI = 0.901$). Additionally, all the items of the 2 factors obtained high factor weights ($\lambda \geq 0.5$) and appropriate individual reliabilities ($R^2 \geq 0.25$) showing good local adjustment and factorial validity (Figure 1).

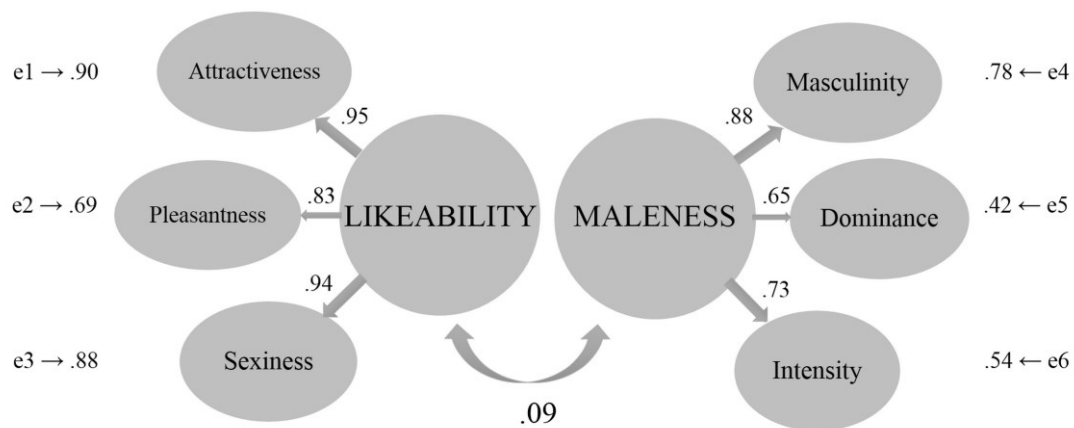


Fig. 1. Confirmatory factor analysis of the factors, Likeability and Maleness. Proportions represent, from centre to periphery, the correlation between factors, factor weights and individual reliabilities, respectively.

The discriminant validity (which assesses whether the items/variables present in a particular factor are not correlated with other factors) was calculated by comparing the Average Variance Extracted (*AVE*) of each factor with the square of the correlation between the 2 factors (Anderson and Gerbing 1988). *AVEs* were evaluated as described by Fornell and Larcker (1981). The resulting value (0.0081) was far below that of the *AVE* values ($AVE_{Likeability} = 0.83$; $AVE_{Maleness} = 0.58$), confirming discriminant validity.

The Cronbach alpha was calculated to assess the internal consistency of the items in each factor. The values obtained for the 2 factors were above 0.7 (Nunnally 1975) indicating an appropriate reliability ($Cronbach \alpha_{Likeability} = 0.929$; $Cronbach \alpha_{Maleness} = 0.793$). Thus, the values of likeability and maleness were calculated taking into account the factor weights of each variable (e.g. $Likeability = Sexiness * 0.94 + Pleasantness * 0.83 + Attractiveness * 0.95$).

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3.3. The influence of skin color masculinity on odor ratings

The following multilevel analyses took into consideration likeability, maleness, arousal, familiarity and health as dependent variables (separate analysis were performed for each of the variables). The color masculinity score predicted positively both likeability (Unstandardized $\beta = 4.44 \pm 1.944$, Wald Chi-square = 5.228, $df = 1$, $p = 0.022$) and health (Unstandardized $\beta = 2.102 \pm .756$, Wald Chi-square = 7.731, $df = 1$, $p = 0.005$). Maleness was predicted negatively by the color masculinity score (Unstandardized $\beta = -8.403 \pm 1.464$, Wald Chi-square = 32.924, $df = 1$, $p < 0.001$). Finally, color masculinity score did not predict ratings of familiarity (Unstandardized $\beta = -.643 \pm .849$, Wald Chi-square = .573, $df = 1$, $p = 0.449$) or arousal (Unstandardized $\beta = 1.756 \pm .955$, Wald Chi-square = 3.377, $df = 1$, $p = 0.066$).

4. Discussion

The main aim of this work was to explore if skin color masculinity had any association with odor judgments of the same participants. To do so, we measured skin color $L^*a^*b^*$ values of male donors and calculated their masculinity index according to a regression model of skin color sexual dimorphism. The body odors of each donor were rated by female participants. Results showed that the donors' skin color masculinity index predicted positively their likeability (attractiveness, pleasantness, and sexiness) and health ratings, but negatively their maleness (masculinity, dominance, and intensity) ratings.

Skin color has been reported as an important determinant of perceived health (Re *et al.* 2011; Stephen *et al.* 2009a; Stephen *et al.* 2011; Stephen *et al.* 2009b). Skin color is also related to reproductive life (Jones *et al.* 2015) and plays an important role in the perception of face attractiveness (Fink *et al.* 2012; Fink *et al.* 2006; Matts *et al.* 2007). It has been found that the way in which skin color influences attractiveness seems to be different for each sex

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(Russell 2003; 2009). Previous studies from Van den Berghe & Frost (1986) and Frost (1988; 1994) have suggested that skin color is sexually dimorphic and that a more typical color of the respective sex is attractive for the opposite sex. According to Carrito *et al.* (2016), a more masculine skin color tends to be attractive for both sexes yet more so for male faces. Using the same methodology of skin color measurement, we found that men with highly masculine color have a body odor perceived not only as more attractive, pleasant and sexy, but also as healthier.

Consistent findings have been reported that more dominant men have a sexier smell than less dominant men (Havlíček *et al.* 2005). Dominant and masculine men might constitute a beneficial choice as partners since they ensure access to resources and protection (Puts 2010). In fact, a recent explanation regarding the mate value of masculinity emphasizes its relation to competitive status-seeking behaviors, more than actual immunocompetence (Scott *et al.* 2010). Despite the controversy surrounding the exact function of masculinity (whether it relates to health and/or competitiveness), masculinity does seem to be attractive when considering preferences for body shape (Little *et al.* 2007), voice (Vukovic *et al.* 2008) and skin color (Carrito *et al.* 2016). It remains unclear why studies exploring face shape report inconsistent results but these might reflect methodological issues (Rhodes 2006).

How skin color is related to body odor production also remains to be known. A recent study by Zuniga and coworkers (2016) found skin yellowness to be positively correlated with body odor hedonic evaluations when female participants rated odors of male donors. The authors claimed that such result represented a preference for odors of possible healthy mates that had a rich diet in fruit and vegetables. However, self-reported fruit and vegetable consumption did not predict the participants' affective evaluation of the odors. Because skin yellowness is sexually dimorphic, as we observed in section 2.2.1, it is possible that Zuniga *et al.*'s (2016) findings represent a preference for odors of men with more masculine color,

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similarly to our study. Body odors are caused by the presence of bacteria in the secretions of the sebaceous and apocrine glands which, in turn, are very frequent in human armpits (Leyden *et al.* 1981). Because sebaceous and apocrine glands develop during puberty (Wyatt 2015), simultaneously with the development of secondary sexual characteristics, it is possible that body odor communicates sexual maturity of the individual. On the other hand, considering the possibility that masculinity is indeed related to health and fitness, the relationship between skin color and odor production may be indirect, with men with more masculine skin color being healthier and consequently having a different odor. The health of the individual is believed to influence body odor, as disease can significantly alter the smell of sweat (Olsson *et al.* 2014; Shirasu and Touhara 2011), so heterosexual women may feel attracted to odors of more masculine, healthier men.

Concerning the results related with the maleness factor, previous findings have demonstrated that the odor of more dominant men is less intense (Havlíček *et al.* 2005) and a similar result was found in the present study for skin color masculinity. An inverse relationship between odor pleasantness and intensity has been reported in other studies (Doty *et al.* 1978; Havlíček *et al.* 2006; Mutic *et al.* 2016). Here, skin color masculinity negatively predicted the maleness factor that included masculinity, dominance and intensity ratings. At first sight, this result might seem unexpected, but it is probably due to the influence of a stereotype from female raters. It is possible that attributions of masculinity to odors are based on an overgeneralization of the stereotypic assumption that men smell worse than women. By such stereotypical overgeneralization, more masculine men should, therefore, smell (even) worse than feminine men. Unable to find literature that supports the existence of the stereotype “Masculine men smell intensely and badly”, we conducted an online survey where female participants, facing an imaginary odor presentation, had to say if the intense/unpleasant odors normally belong to more or less masculine/dominant men (see data

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in supplementary material). As predicted, women associated the intense and unpleasant odors to hypothetical more masculine and dominant males. By this, we conclude that these findings probably result from the influence of a stereotype. This conclusion is supported by Mutic *et al.*' findings (2016) that suggest that both women and men are unable to correctly attribute masculinity ratings to odors. They found a masculinity bias in human odor since body odors tended to be rated as masculine, regardless of the sex of the donor. Their results were also interpreted as resulting from masculine gender stereotypes, with intense body odor being judged as originating from dominant and physically strong men.

More studies exploring the association between preferences for facial masculinity and odor preferences are needed since, to our knowledge, there is little evidence of this relationship. Despite the number of studies linking (face and body) symmetry and odor attractiveness (Rikowski and Grammer 1999; Thornhill *et al.* 2013; Thornhill and Gangestad 1999; Thornhill *et al.* 2003), facial masculinity has been neglected by recent studies of odors (except for Allen *et al.* 2016). As mentioned before, higher masculinity, when measured through the levels of testosterone, seems to enhance the attractiveness of odors (Thornhill *et al.* 2013). Other studies have investigated sexually dimorphic preferences in odor cues, through preferences for putative pheromones (Cornwell *et al.* 2004). The use of putative pheromones has been criticized by some authors who claim that there is insufficient evidence that the compounds identified so far are actual pheromones (Wyatt 2015). For this reason, studies that use body odors are more ecologically valid than studies of preferences for putative pheromones.

It would also be of interest to test preference for odors of same-sex individuals to evaluate whether the preferences reported here and in similar studies (e.g. Zuniga *et al.* 2016) do in fact represent mate choice mechanisms or if they simply account for a need of individuals to be surrounded by healthy others in order to avoid infectious diseases. Carrito *et*

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al. (2016), when evaluating preferences for skin color masculinity in faces, found that female participants masculinized both male and female faces, noticing, however, that male faces were consistently more masculinized than the other face group. This difference in face color preferences, showed skin color masculinity to be especially important when women judge male faces, which might be taken as a possible mate choice strategy. Regarding odor preferences, if such difference was evident between same and other-sex odors, similar conclusions could be reached and a mate choice relevance would be indicated. Future studies should also try to understand if the menstrual cycle phase of the raters influences their preferences for odors of men varying in skin color masculinity. Such analyses were not performed in this work given the unequal number of female participants present in each group (only 10 female raters were in the fertile phase while the other 31 were in the non-fertile phase of their menstrual cycle).

To our knowledge, this study was the first to explore the relationship between skin color masculinity and odor attractiveness. The results show that females prefer the odor of men with more masculine face skin color. Our findings support the idea that chemosensory communication is important in the context of reproductive success (Lübke and Pause 2015) and that humans, like other animals, use olfactory signals for the transmission of information that is biologically relevant (Grammer *et al.* 2005).

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Supplementary Material

With the aim of better understanding the reason why donors with high skin colour masculinity had their body odours rated as less masculine and less dominant, an online survey was conducted to investigate the stereotypical notion of what masculine/dominant men smell like. Questions were formulated about judgements of male odour intensity and unpleasantness, considering the masculinity and dominance of the donor.

1. Participants

A hundred and sixty-six women responded voluntarily to one of four questions. All of them were Caucasian and were more than 18 years old but less than 38 ($M_{age} = 24.13$; $SD = 4.84$). The number of participants that responded to each of the four questions was 43 for question 1; 40 for question 2; 43 for question 3; and 40 for question 4.

2. Procedure

The questions/answers were formulated with a common starting scenario: “Imagine that you are sensing the odour of two different men (natural odour – without perfume or deodorant)”. Participants responded to only one of the following questions:

1. Which of the odours is more intense? Possible answers: (a) the more masculine; (b) the less masculine.
2. Which of the odours is more intense? Possible answers: (a) the more dominant; (b) the less dominant.

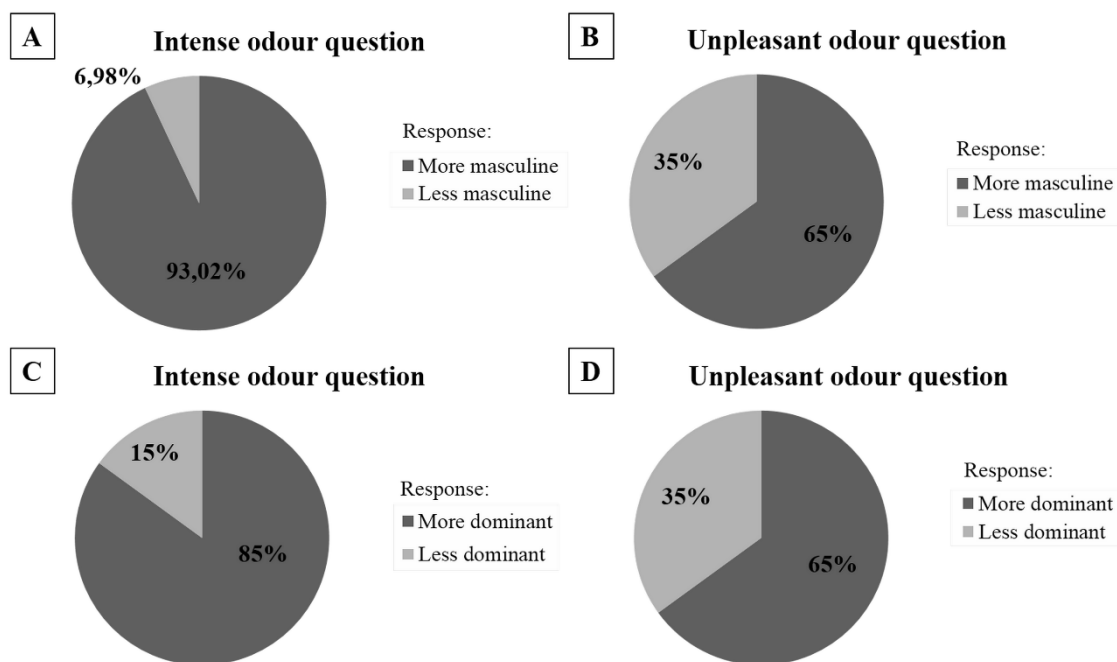
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3. Which of the odours is more unpleasant? Possible answers: (a) the more masculine; (b) the less masculine.

4. Which of the odours is more unpleasant? Possible answers: (a) the more dominant; (b) the less dominant.

3. Results

The “more masculine man” option was selected by 93.02% of participants for the more intense odour scenario (Supplementary Figure 1A) and by 65% of participants for the more unpleasant odour scenario (Supplementary Figure 1B). Similarly, the “more dominant man” option was selected by 85% of participants for the more intense odour scenario (Supplementary Figure 1C) and by 65% of participants for the more unpleasant odour scenario (Supplementary Figure 1D).



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Supplementary Figure 1. Percentage of more masculine and less masculine (A and B) and more dominant and less dominant (C and D) responses to the hypothetical scenario of sensing an intense (A and C) or unpleasant (B and D) body odour.

As predicted, women associated the intense and unpleasant odours to more masculine/dominant males.